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Rapid Communication

The enigmatic blue-green iridescence of *Sapphirina ovatolanceolata* (Dana, 1849) (Crustacea, Copepoda, Sapphirinidae): a live observation from the Lakshadweep waters

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Abstract

The marine planktonic cyclopoid copepod genus *Sapphirina* is renowned for its striking iridescence, yet in situ observations of this phenomenon are relatively rare. This structural iridescence arises from the interference and reflection of light by thin, multilayered hexagonal guanine crystal platelets in the integument. The dazzling colors, which range from red to blue or violet, vary among species and are displayed exclusively by males. This feature likely serves as an adaptation for mate recognition, intraspecific communication, and predator avoidance through rapid shifts to transparency. During a field expedition near Kavaratti Island in the Lakshadweep archipelago (India) in January 2020, we observed a distinctive "jeweled" appearance of the seawater surface at about 8:30 AM. Investigation revealed that the phenomenon was caused by a swarm of *Sapphirina ovatolanceolata* males exhibiting brilliant blue-green iridescence. This short communication documents the occurrence and identification of *S. ovatolanceolata* from Lakshadweep waters, providing live photographic evidence of its blue-green iridescence in the natural environment.

Key words: Indian Ocean, iridescence, Kavaratti, optical adaptation, pelagic copepods

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Introduction

The genus *Sapphirina* (Copepoda: Cyclopoida, family Sapphirinidae), commonly known as the "sea sapphires" comprises small pelagic copepods famed for the vivid, gem-like iridescence of their males. This optical phenomenon has long fascinated marine biologists and has recently attracted interest from oceanographers and materials scientists for its unique photonic properties. The iridescence in *Sapphirina* is produced by microscopic layers of guanine crystals in the cuticle that form a multi-layer reflector. Light interference in these crystal plates causes males to flash intense colors (red, blue, violet, etc.) that can turn the sunlit ocean surface into "jeweled water" when the animals aggregate near

the surface (Chae et al. 1996; Takahashi et al. 2015). Females, by contrast, lack these reflective structures and remain transparent. The striking coloration of *Sapphirina* males is thought to function in mate recognition and communication, while their ability to switch to near-invisibility by adjusting the iridescence or orientation provides an antipredator strategy (Chae and Nishida 1994; Vestheim and Kaartvedt 2006). Indeed, the shimmering display is only visible from certain angles and disappears when the male turns its body or when ambient light conditions change, aiding camouflage.

Sapphirina ovatolanceolata (Dana, 1849) is one of the larger species in this genus (adult males ~2.5–3 mm long) and can exhibit a brilliant blue-green iridescence. Taxonomically, *S. ovatolanceolata* belongs to the order Cyclopoida (formerly Poecilostomatoida) and family Sapphirinidae, and like its relatives it is an epipelagic copepod often found in warm oceanic waters. It was originally described from the Indo-Pacific and has a broad tropical/subtropical distribution. Published records indicate *S. ovatolanceolata* occurs in the Pacific and Atlantic Oceans, the seas around Southeast Africa, northeastern and eastern Australia, and across the Indo-West Pacific including the Bay of Bengal, Andaman Sea, Strait of Malacca, Arabian Sea, and Persian (Arabian) Gulf (Razouls et al. 2025). In Indian waters, the species has been documented from the Bay of Bengal and Arabian Sea, but to our knowledge its presence had not been confirmed in the Lakshadweep archipelago prior to this study. Moreover, observations of live iridescent individuals in the field are scarce in the literature, as most records come from net sampling and preserved specimens.

Here we report an in-situ observation and collection of *Sapphirina ovatolanceolata* from the coastal waters of Kavaratti Island in Lakshadweep, highlighting the male's blue-green iridescence under natural conditions. The rationale for studying this species at this location stems from both biogeographic interest (filling a gap in its known distribution) and the opportunity to document the elusive iridescent display in a live state. The following account provides details on the taxonomy, ecology, and behavior of *S. ovatolanceolata* as observed in Lakshadweep waters.

Materials and methods

Sampling location and collection

Zooplankton sampling was conducted on the eastern side of Kavaratti Island (Lakshadweep, Southeastern Arabian Sea) during a morning survey in January 2020. Although the field observation occurred in January 2020, the analysis and write-up of these findings were completed later due to delays caused by the global COVID-19 pandemic. Around 08:30 h local time, multiple bright blue-green flashes were noticed in the upper water column (surface to ~10 m depth), appearing as "glowing" points in the sunlight. These patches were targeted for collection using a standard Bongo plankton net (200 µm mesh, mouth area of 0.25 m^2 and length 2.5 m) fitted with a calibrated flowmeter (Omori and Ikeda 1984; Harris et al. 2000). The net was towed obliquely from ~10 m depth to the surface in the areas where the flashes were observed. Upon retrieval, the plankton sample itself exhibited visible iridescent flashes (a phenomenon that

continued as the copepods swam in the container). All samples were promptly preserved once documentation was done. Live specimens were observed briefly in a tray of seawater for photography, then fixed in 4% buffered formaldehyde. Notably, the shimmering blue-green colors persisted in the live sample but disappeared upon fixation, as expected. In addition, preserved specimens are retained in the reference collection of Marine Biology Museum of Cochin University of Science and Technology (Cochin, India).

Environmental parameters

A Conductivity-Temperature-Depth profiler (Sea-Bird Electronics SBE 911 CTD) was deployed at the site to record water properties. The sea surface temperature at the time of collection averaged 29.8 °C (±0.2 °C), with a salinity of ~35.1 psu and dissolved oxygen of ~5.0 mL L^{-1}. The water column at the station was approximately 40 m deep. Weather conditions were clear and sunny, providing strong illumination for iridescence at the surface.

Species identification and measurements

The copepods responsible for the observed iridescence were isolated and identified morphologically as *Sapphirina ovatolanceolata*. Identification was carried out under a stereomicroscope on both the fresh (temporarily live) specimens and on preserved individuals, using standard taxonomic keys and original species descriptions (Thompson 1829; Dana 1853; Giesbrecht 1892; Crisafi and Mazza 1966; Conway 2003; Razouls et al. 2025). Diagnostic features including body shape, proportions, and appendages were examined. Total body length (+CR) was measured for adult males using ScopePhoto (×64) software and was recorded to the nearest 0.01 mm. Photographs of the specimens were taken to document both the transparent and iridescent states.

Results

Field observations

In the field, the presence of *Sapphirina* was first indicated by the water surface appearing to sparkle with intense blue-green points of light. These flashes were highly angle-dependent and transient; as the sunlit viewing angle shifted with wave action, the copepods alternated between shining bright turquoise and vanishing from sight, rendering the water momentarily “jeweled” and then clear again. Upon capture, we confirmed that these optical effects were produced by several small copepods (~2–3 mm in length) swimming actively in the sample. All the visibly iridescent individuals were identified as adult male *Sapphirina ovatolanceolata*. No iridescence was observed from any female *Sapphirina* (if present, females would have remained transparent and inconspicuous in the sample). After a few minutes in the container (and particularly after fixation in formalin), the living blue-green flashes faded and the copepods became essentially transparent, consistent with the known fragility of the iridescent structures once the animals are no longer alive.

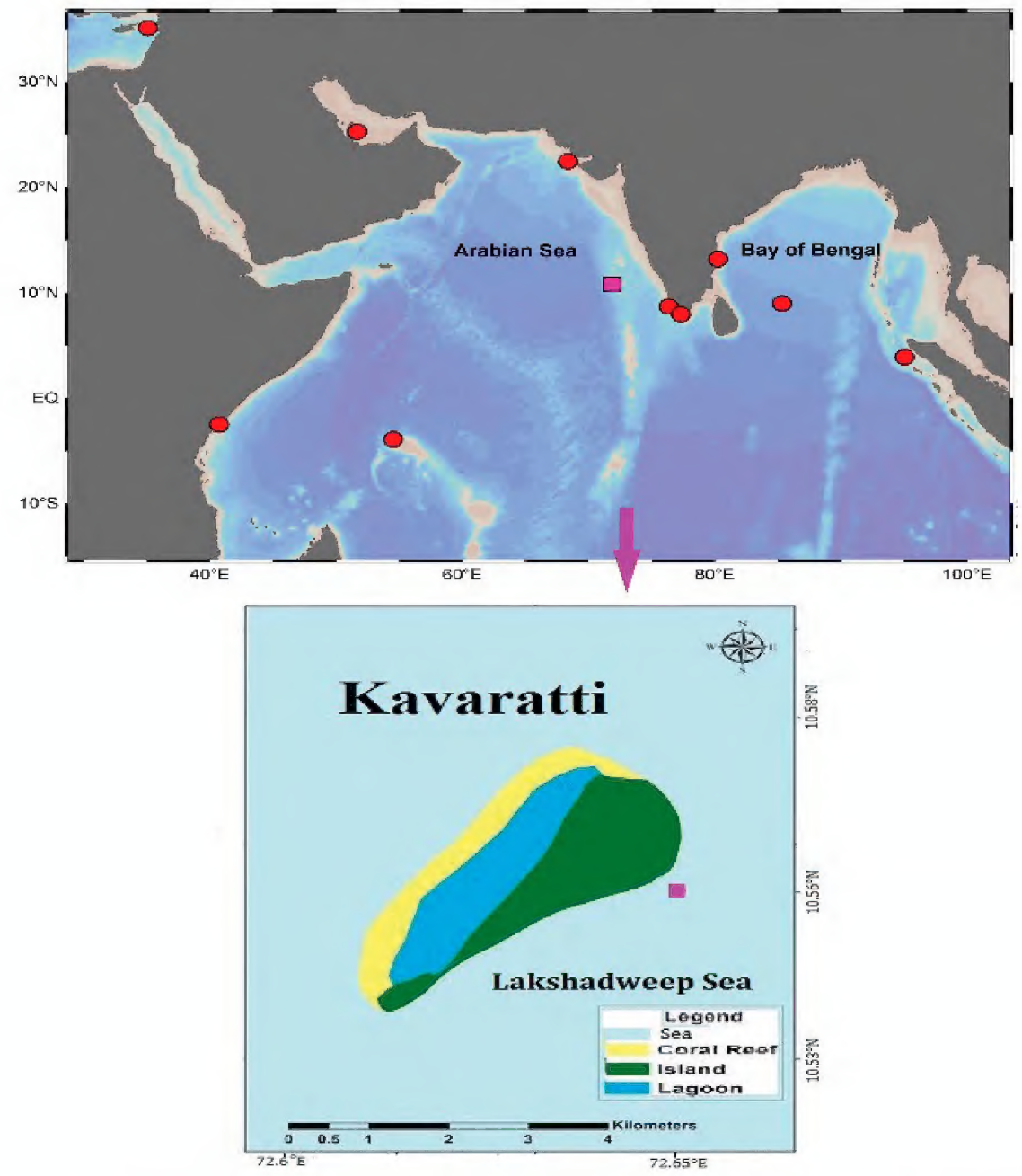

Figure 1. Map showing the collection locality and distribution records of *Sapphirina ovatolanceolata* in the Indian Ocean. The square symbol (magenta colour) indicates the present record at Kavaratti Island (Lakshadweep archipelago), and circles (red colour) indicate previous reported occurrences of the species in surrounding regions (historical literature records).

Morphological identification

The male specimens of *S. ovatolanceolata* in our sample ranged from 2.30 to 3.19 mm in total length (including caudal rami). They possess a semi-transparent, elongated and dorsoventrally depressed body (flattened top-to-bottom). The cephalosome (head and first thoracic segments) is wider than it is long, with a distinctly pointed frontal margin (anterior end). Dorsal eye lenses or "cuticular lenses" are not visible on the top of the head in this species, which is a useful diagnostic trait distinguishing it from some other *Sapphirina* species that have noticeable dorsal lens patches. The antennules (A1) are five-segmented. The urosome terminates in elongated ovate caudal rami (tail appendages) that give the species its name ("ovatolanceolata"). Overall, the morphology matched published descriptions of *S. ovatolanceolata* (Crisafi and Mazza 1966; Razouls et al. 2025). Fig. 2a shows the habitus of a preserved male specimen (dorsal view), illustrating the general body shape and proportions. In life, the males were nearly invisible when viewed head-on or from below, but when viewed from certain angles in direct light they produced a brilliant metallic blue-green sheen (Fig. 2b). This iridescence manifested as bands or patches of color on the dorsal surface of the animal, shifting with slight changes in orientation. The combination of these morphological and optical characteristics confirmed the identity of the species as *S. ovatolanceolata*.

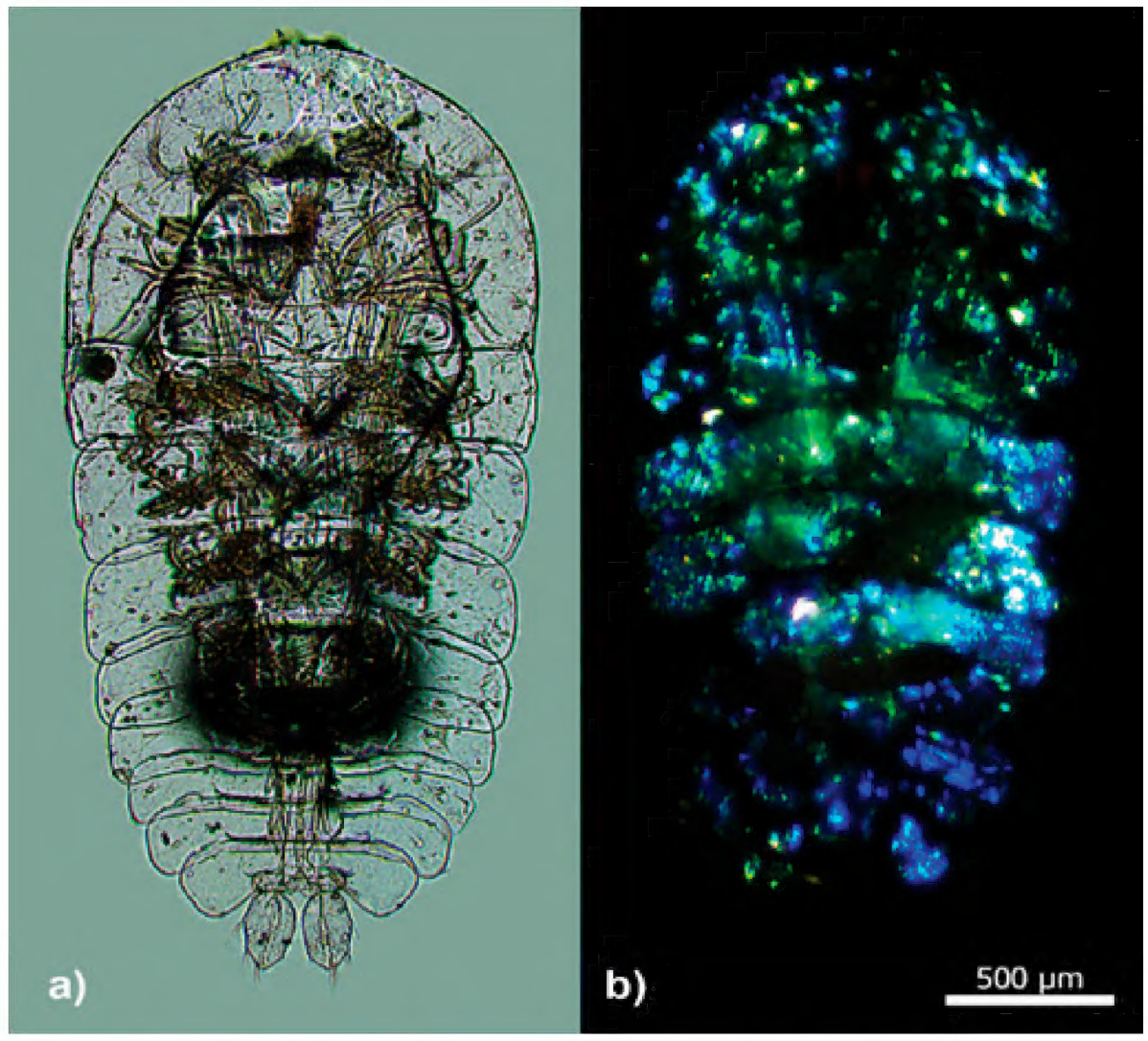

Figure 2. a. Dorsal view of a preserved male *Sapphirina ovatolanceolata* (habitus), showing the transparent body and elongate caudal rami; **b.** A live male *S. ovatolanceolata* from Kavaratti waters displaying brilliant blue-green iridescence.

Discussion

This live observation of *Sapphirina ovatolanceolata* males with a striking blue-green iridescence in Lakshadweep waters provides a rare live documented case of this phenomenon in the Southeastern Arabian Sea. The brilliant metallic blue-green hue (~500 nm wavelength) exhibited by the males is consistent with previous optical measurements for this species. Chae and Nishida (1999) reported that *S. ovatolanceolata* males have major reflectance peaks between approximately 430 nm and 600 nm, corresponding to a blue-green coloration. In fact, they measured a peak reflectivity around 506 nm for this species, which closely matches the color we observed in the field. Our field sighting thus corroborates those laboratory spectral data – the copepod's structural reflector produces its intended blue-green signal under natural sunlight, confirming that the phenomenon is not an artifact of lab observation but indeed occurs in nature.

It is noteworthy that the iridescence in *Sapphirina* is highly dependent on the live condition and orientation of the animal. As seen in this study, once the copepods were frozen or fixed in preservative, the iridescent colors vanished. This agrees with the reports in the literature that the reflective guanine platelets require intact cellular spacing and hydration to function, and that the colors fade upon death or desiccation. Takahashi et al. (2015) documented a related effect in *Sapphirina nigromaculata*, where males shift from iridescent to transparent on a daily cycle. In that species, live males were observed to display vivid iridescence during the daytime but became essentially invisible at night – a diel color change that likely serves to maximize mating signals when sunlight is available and to minimize predation risk after dark. Transparency is arguably

the best camouflage in sunlit surface waters, and *Sapphirina* males appear to exploit a dynamic strategy, they can sparkle like a sapphire when they want to be seen, and disappear when they need to hide. In our *S. ovatolanceolata* observation, the animals were actively flashing in the morning light, and it is conceivable that this timing is linked to daily behavioral patterns similar to those of *S. nigromaculata*. Indeed, some sapphirinid copepods exhibit "reverse" diel vertical migration, wherein males ascend toward the surface in daytime to signal to mates despite increased visibility to predators (Chae and Nishida 1995; Takahashi et al. 2015). The occurrence of multiple *S. ovatolanceolata* males near the surface at morning hours, when light intensity is high, aligns with this strategy and suggests that these males may have been positioning themselves for maximal visual communication (e.g. to attract females or deter rival males) during daylight. Such behavior underscores the ecological trade-off these copepods navigate, they must be conspicuous enough to find each other in the vast ocean, yet not so conspicuous as to be easily caught by predators.

Comparative observations of iridescence across the genus *Sapphirina* reveal interesting interspecific differences. Each species tends to have its own signature hue and spectral pattern (Chae and Nishida 1999). For example, *Sapphirina angusta* and *S. opalina* produce predominantly violet-blue reflections (with spectral peaks around ~420 nm) (Chae and Nishida 1999; Gur et al. 2015; Gur et al. 2016). On the other hand, *S. auronitens* and *S. gastrica* are known for golden or yellow-green iridescence, with dominant reflection at wavelengths longer than ~500 nm (Chae and Nishida 1999). *Sapphirina metallina* is reported to exhibit multiple color variants with a broader range of reflective peaks (Chae and Nishida 1999). These variations are attributed to differences in the structure and spacing of the guanine crystal layers in the cuticle, as well as possible pigmentation in the underlying tissues (Chae and Nishida 1999). In *S. angusta* and *S. opalina*, for instance, a secondary long-wavelength peak (>750 nm) has been noted, which might be due to a thin layer of red pigment beneath the reflector or a second-order interference effect (Chae and Nishida 1999). Such diversity in optical traits suggests that each *Sapphirina* species has evolved its iridescence to suit its specific ecological context, perhaps tuning its signal to the ambient light conditions of its preferred depth range or to the visual sensitivity of its intended audience (conspecifics).

The ecological significance of *Sapphirina*'s dazzling colors is still being investigated, but several functional hypotheses have gained support. One hypothesis is that the iridescence enhances the contrast of males against the ambient light at their daytime depth, effectively making them more visible to females in the same habitat. Chae and Nishida (1999) proposed that the spectral properties of each species iridescence might be adapted to the lighting environment where that species typically resides, thereby increasing the distance over which individuals can visually detect each other for mating. In the case of *S. ovatolanceolata*, its blue-green coloration would be well-suited for relatively clear, blue oceanic waters, especially a few tens of meters below the surface where blue-green light predominates. Conversely, the ability to become transparent is clearly advantageous for avoiding visually hunting predators such as fish. By switching between an eye-catching mode and a stealth mode, Sapphirinid copepods can balance the conflicting demands of reproduction and survival (a form of

"plasticity in coloration" as noted by Vestheim and Kaartvedt (2006). This dual strategy is quite unique among zooplankton; many other plankters rely solely on transparency or diel migration to avoid predation, whereas *Sapphirina* adds the element of a transient, ultra-reflective display when needed.

In our observation, we also found that multiple males of *S. ovatolanceolata* were present simultaneously in a small area. This could imply an aggregation event, possibly related to mating, although our snapshot alone cannot confirm the purpose. We did not observe any overt interactions or the presence of females, so the exact cause of the clustering remains uncertain. Unlike some planktonic organisms that swarm for spawning, *Sapphirina* are not well-documented in that regard, but the coincident appearance of several iridescent males in the same vicinity suggests they might have been responding to a common cue (such as the early morning light level or the presence of a food source or females). Further targeted observations (for example, using underwater video or plankton imaging systems) could shed light on whether *S. ovatolanceolata* and its kin actively form mating aggregations at the surface.

Finally, this report adds a new regional record for *Sapphirina ovatolanceolata* and illustrates that even very small pelagic crustaceans can produce visually stunning natural phenomena. The "sea sapphire" effect near Lakshadweep emphasizes how little we directly observe of the open ocean plankton community, brief events like these can easily go unnoticed, yet they may play subtle roles in marine ecosystems. Gelatinous zooplankton (salps and doliolids) are known to be preyed upon by sapphirinid copepods (Takahashi et al. 2013), and perhaps the bright signals serve in prey distraction or other interactions in ways not yet understood. We refrain from speculation beyond current evidence, but note that *Sapphirina* spp. epitomize the complexity of planktonic life: they have evolved an extraordinary structural coloration mechanism, comparable to that of butterflies or peacock feathers, yet deploy it in a context of clear seawater where both being seen and not being seen can be a matter of life and death.

In conclusion, the live observation of *Sapphirina ovatolanceolata* in Lakshadweep waters contributes valuable information on the species morphology, distribution, and behavior. It underscores the importance of in situ observations for understanding the natural history of planktonic organisms that are often only studied from net samples. We have provided a detailed account addressing taxonomy, identification, and the phenomenon of iridescence. This short communication serves to document the occurrence of a "sea sapphire" in Indian coastal waters and to discuss the broader biological significance of its iridescence. Future studies integrating behavioral observations, optical measurements, and perhaps genetic analyses of *Sapphirina* will further illuminate how these tiny creatures make such a brilliant splash in the ocean's tapestry.

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Additional information

Conflict of interest

The authors have declared that no competing interests exist.

Ethical statement

No ethical statement was reported.

Use of AI

No use of AI was reported.

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Author contributions

R.R., P.R.J. & S.B.N.: Conceptualization, Methodology, Software. R.R. & P.R.J.: Data curation, Writing – Original draft preparation: P.R.J. & R.R. Visualization, Investigation. S.B.N.: Supervision. R.R., P.R.J., S.K.S.: Writing – Reviewing and Editing. All authors read and approved the manuscript.

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Data availability

All of the data that support the findings of this study are available in the main text.

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